1. Introduction

There are various attempts to analyze the structural integrity of axially cracked pipelines [1]. In this study a fracture-mechanics approach is used to predict the fracture condition of linepipe steel pipes. The approach utilizes simple approximate expressions for determining fracture parameters K, J, concerning the axial part - through thickness cracks in a pipe wall, and it employs these parameters to determine the critical dimensions of a crack on the basis of equality between the J integral and the J-based fracture toughness of the pipe steel. The crack tip constraint is accounted here by the so-called plastic constraint factor on yielding given by

\[ C = \frac{\sigma_1}{\sigma_{HMH}} \]

where \( \sigma_1 \) is the max. primary stress and \( \sigma_{HMH} \) is the Huber–Mises-Hencky stress.

The method was verified in burst tests of pipes made from steels X52, X65 and X70. Mechanical and fracture properties of the steels are in Tab.1.

<table>
<thead>
<tr>
<th>Steel</th>
<th>X52</th>
<th>X65</th>
<th>X70</th>
</tr>
</thead>
<tbody>
<tr>
<td>( R_{p0.2} ) (MPa)</td>
<td>395</td>
<td>496</td>
<td>536</td>
</tr>
<tr>
<td>( R_m ) (MPa)</td>
<td>502</td>
<td>582</td>
<td>643</td>
</tr>
<tr>
<td>( J_c ) (N/mm)</td>
<td>415</td>
<td>432</td>
<td>439</td>
</tr>
</tbody>
</table>

Tab.1: Mechanical and fracture-mechanical properties of the steels
After the starting slits were made, the test pipes were subjected to water pressure cycling to produce fatigue cracks in the tips of the starting slits. The cycling was carried out in a pressurizing system, which included a high-pressure water pump, a collecting tank, a regulator designed to control the amount of water that was supplied and, consequently, the rate at which the pressure is increased in the pipe section.

In cycling the cracks, the water pressure fluctuated between \( p_{\text{min}} = 1.5 \text{ MPa} \) and \( p_{\text{max}} = 5.3 \text{ MPa} \), and the number of pressure cycles was between 3 000 and 4 000. The period of a cycle was approximately 150 seconds. Then the pipe sections were loaded by increasing water pressure to burst. Summary results are presented in Tab. 2.

![Graph](image_url)

As is evident from Fig. 3, the intersection of the straight line \( J = J_{\text{cr}} = 439 \text{ N/mm} \) with the two \( J - a \) curves gives the value \( a_{\text{cr}} \approx 7.05 \text{ mm} \), which is well consistent with the crack depth \( B \) \( a_{\text{cr}} = 7.1 \text{ mm} \) established experimentally.

### 4. Conclusion

An engineering method has been worked out for assessing the geometrical parameters of critical axial crack-like defects in the wall of high-pressure cylindrical shells.

### 5. Acknowledgements

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### 6. References
